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Article *in* Materials today: proceedings · February 2020

DOI: 10.1016/j.matpr.2020.01.192

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ANSYS – A bibliometric study

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ARTICLE INFO

Article history:
Received 13 October 2019
Received in revised form 23 October 2019
Accepted 8 January 2020
Available online xxxx

Keywords:
ANSYS
Bibliometric
VOSviewer
Web of science
Finite Element Method

ABSTRACT

ANSYS is a general-purpose finite-element method tool deployed to numerically solve a wide range of engineering problems. Therefore, this paper presents a bibliometric analysis of research studies conducted using ANSYS. The work uses the Web of Science database to analyze the most active authors, institutions, countries and the most popular keywords used in the ANSYS research field. Based on the search phrase "Analysis using ANSYS" and "Analysis in ANSYS", 359 articles were retrieved and they span between 1989 and 2019. Using bibliometric software (VOSviewer), graphical visualization of the bond between the authors, institutions, countries and keywords with bibliometric co-citations and collaborations were established. Based on the available data, it was found that Chinese and Indian authors are the most productive researchers in the field of ANSYS. This paper will assist industries, both old and new researcher with a keen interest in pursuing ANSYS related research to establish research collaborations or secure research funds from companies, government or individuals.

Selection and of the scientific committee of the 10th International Conference of Materials Processing and Characterization.

1. Introduction

Recently, the advancement in computer technology has provided the means of calculating and analyzing the stress in various engineering structures using the method of Finite Element Method (FEM) [1]. The Finite Element Analysis (FEA) was first introduced in the year 1956 by Turner et al. [2]. It is a computational approach used in approximating complex real-world engineering problems within certain boundary conditions. It is a vital process that is utilized in designing and also modelling of physical engineering matter (solid, liquid or gaseous). The basis of FEA depends on the disintegration of the domain into a number of components for which the methodical approximate solution is built using weighted residual approaches [3]. In addition, FEA reduces the problem by separating the domain into elements and sharing the unidentified variable in regards to the presumed approximating features within each element. These interpolation features are specified in regards to the filed variables at certain nodes situated along the element boundary. The capability to discretize the uneven domain makes the approach a useful evaluation tool for eigenvalue boundary problem [4]. FEA is the frequently utilized computational tool for screening as well as changing design structures within particular design limitation. It entails dividing the structure into tiny components referred to as 'Elements' for static and also dynamic analysis of simple to intricate structures under various design constraints [5]. The use of the FEM as a tool to handle design issues in commercial applications is rather brand-new. In the late 1950's, manual computations were used and a force-based technique was employed contrast to the displacement method used today. In the mid 60's, analysis was performed using extremely specialized computer programs and then business programs began to arise around the 1970's. In the beginning, FEM was restricted to the data processor in computer that was costly and owned by the defence, aeronautics, and nuclear industries. Then, in the late 70's its usage began to expand as such more firms began to utilize the FEM [6].

ANSYS was the initial name for ANSYS Mechanical or ANSYS Multiphysics, general-purpose finite element analysis software. A series of CAE products were established by ANSYS Inc, but still it is best understood for ANSYS Mechanical & ANSYS Multiphysics. The scholastic variations of these products are described as ANSYS Academic Research, ANSYS Academic Teaching Advanced and so on. Every one of them is a general-purpose analysis tool having pre-processing solver as well as post-processing. Among the

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https://doi.org/10.1016/j.matpr.2020.01.192
2214-7853/
Selection and of the scientific committee of the 10th International Conference of Materials Processing and Characterization.

benefits of "ANSYS" is the user-programmable capacity. The ANSYS Command Language has numerous commands connecting to geometry generation, mesh, constraints, solver setups and lots of various other attributes. If numerous analysis is needed with various specifications, loops can be made use of to alter the specifications, or an optimization component can be made use of to immediately handle parameter updates/changes [7]. This paper presents a bibliometric analysis of the published articles under the topic analysis using ANSYS in Web of Science database between the year 1989 to date (2019).

2. Methods and data

2.1. Methods

Bibliometric analysis is a methodical technique to quantitatively examine scholastic literary works in order to determine the study patterns produced [8]. Bibliometric analysis was initially used in information and library science. However, it has actually been used in different areas to gauge research development [9]. The applications of bibliometric analysis typically concentrate on examining the publication dispersed pattern, authors, journals, institutions, countries and research study area. BibExcel is one of the commonly used bibliometric tool kit, which is normally made use of to refine scholastic bibliographic information obtained from Web of Science, Scopus, and also various other mainstream data sources [10]. Citespace is a detailed visualization tool developed by Professor Chen Chaomei's group, which can evaluate as well as picture scientific research works. Via visual display, the intellectual landscape of a particular research knowledge can be obtained [8].

In this research, VOSviewer software [11] is the tool employed in the analysis. Authors, institutions, countries and keywords were represented by circular nodes to evaluate the research study partnership network.

2.2. Data source

Numerous databases are used to index articles among which are Web of Science (WOS), Elsevier's Scopus, Science Direct, IEEE Explore, Springer Google Scholar, and ACM (Association for Computing Machinery). However, the top major database used for bibliometric analysis are WOS, Elsevier's Scopus and Google Scholar [12–14]. A prominent global journal citation database used for bibliometric evaluation is the ISI Web of Science (WOS) developed by Thomson Reuters [15]. The documents extracted from WOS are believed to be of higher quality standard and data format is easily compatible with VOSviewer software as compared to the other two prominent databases (Scopus, Google scholar). WOS is the most acknowledged scholastic database which has actually been internationally used to evaluate research performance. A bibliometric study has been conducted in [16] using the database. WOS data source was the only tool for bibliometric evaluation till the production of Scopus and Google Scholar in 2014 [14,17,18] and also, about 94% of Scopus highest possible influence journals were indexed in WOS [19].

In this study, WOB was used as the database to retrieve the data on 2019.10.08. "Analysis using ANSYS" was the search keywords used with the time span set from 1989 to until date (2019). Subject search implies search from titles, abstracts, as well as article keyword phrases. All displayed articles were used for the bibliometric analyses making a total of 359 publications.

2.3. Chronological distribution

The chronological distribution pattern of articles for the extracted data is shown in Fig. 1. The first "ANSYS" related article was a conference paper released in 1989. This article (Bolted joint analysis using ANSYS super elements and gap elements) was written by Sun [20]. Prior to 2005, the numbers of yearly published articles were not more than 5, and zero in a number of years. The rapid increase in the publication number can be seen in the year 2012, with an overall total of 25 publications. Since then, the annual number of publications have been increasing attaining a peak of 41 in 2017 and 2018, 21 in 2019 and still counting.

2.4. Analysis of journals

With regards to the source journals, the 359 articles were published by some reputable journals. Table 1 reveals the top 6 most active journals having the highest number of published ANSYS research topic. Applied Mechanics and Materials was one of the most productive journals with 18 articles, making up 5.014% of the total publications followed by Advanced Materials Research. The 3rd most active journal was Materials Today Proceedings, with 10 publications as well as accounting for 2.786% of the overall publications.

2.5. Authorship analysis

In total, 1133 authors published ANSYS related documents with Santra P. being the most productive author having 7 articles. Chaudhuri P published 6 articles ranking the 2nd followed by

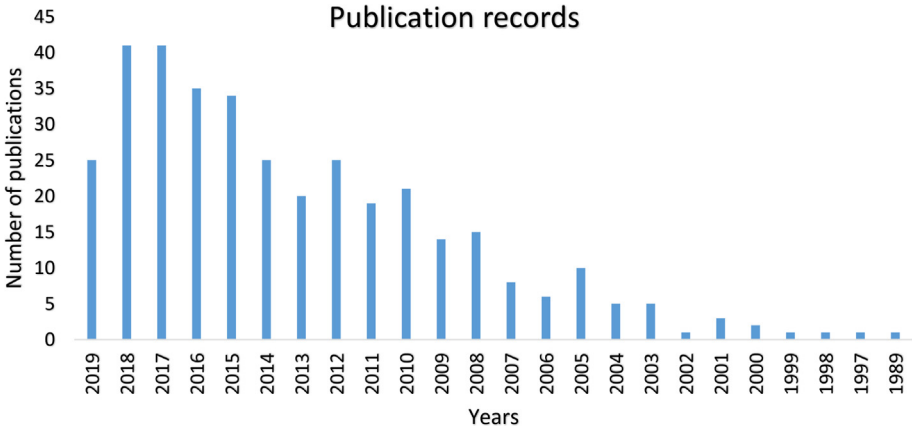

Fig. 1. Chronological distribution of journal publications.

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Table 1
Top 6 most productive journals.

Journal Titles	Records	% of 359
Applied Mechanics and Materials	18	5.014
Advanced Materials Research	13	3.621
Fusion Engineering and Design	9	2.507
Thin Walled Structures	4	1.114
Composite Structures	3	0.836
Computers and Concrete	3	0.836
Energy	3	0.836
Facta Universitatis Series Mechanical Engineering	3	0.836
Fusion Science and Technology	3	0.836
Journal of Intelligent Material Systems And Structures	3	0.836
Journal of Mechanical Science And Technology	3	0.836
Smart Materials And Structures	3	0.836
Advances in Mechanical Engineering	2	0.557
Bio Medical Materials And Engineering	2	0.557
Composites Part A Applied Science And Manufacturing	2	0.557
Engineering Mechanics	2	0.557
Engineering Structures	2	0.557
Finite Elements in Analysis And Design	2	0.557
Geosynthetics International	2	0.557
IEEE Transactions on Applied Superconductivity	2	0.557
International Journal of Heat And Mass Transfer	2	0.557
Journal of Engineering Science And Technology	2	0.557
Journal of Materials Processing Technology	2	0.557
Journal of Micromechanics And Microengineering	2	0.557
Journal of The Brazilian Society Of Mechanical Sciences And Engineering	2	0.557
Journal of Vibroengineering	2	0.557
Journal of Zhejiang University Science A	2	0.557
Key Engineering Materials	2	0.557
Materials Design	2	0.557
Sensor Review	2	0.557
Structural Safety	2	0.557

Table 2
The top 3 most productive authors.

Authors	Records
Santra P	7
Chaudhuri P	6
Ghanbari A	4
Hosseini SAA	4
Khirwadkar S	4
Machacek J	4
Park S	4
Reddy DC	4
Saxena YC	4

Ghanbari A., Hosseini S.A.A., Khirwadkar S., Machacek J., Park S., Reddy D.C. and Saxena Y.C. with 4 publications each (see Table 2).

The cooperation between various authors can be examined by co-authorship network. Fig. 2 reveals the co-authorship network that exists among the ANSYS researchers. As seen in the figure, there are two 2 clusters with the left one being more densely than the other. The node stands for an author, and the node size and the emanating lines signify the author's number of publication and the co-authorship links between the authors. Connected nodes stand for research collaboration between among the authors. Moreover, the density or thickness of the lines shows the collaboration strength between them. As seen, it is obvious that the collaboration in this study is not extremely close with just two clusters. Researcher such as Im K. serves as the intermediary between the two clusters. While Kim, J.S., Kwon, S. and Kim, K.M. are the major co-authors in the red clusters suggesting that the most active authors have more collaborations. Nevertheless, there could be some prejudice in the analysis of authors as some many have initials or changed or shortened names. Authorship evaluation might be prejudiced due to the fact that some writers might have the very same preliminary names, as well as some writers might have released documents by utilizing (e.g., names transformed due to marital relationship) [21]. Therefore, it is critical to developing a one-of-a-kind identification for each and every writer to prevent such mistakes [22].

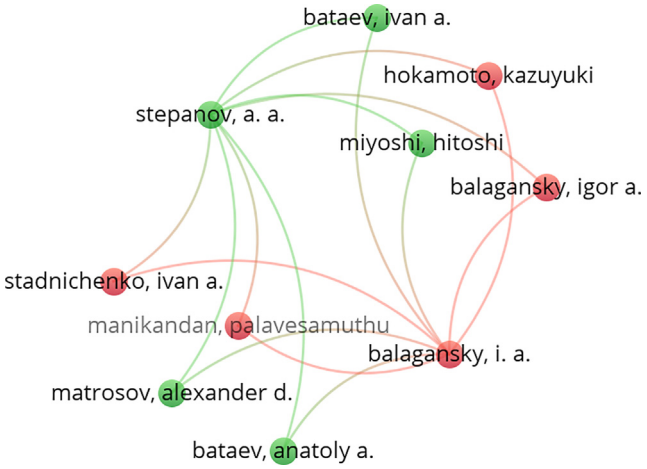

Fig. 3. Authors citation network.

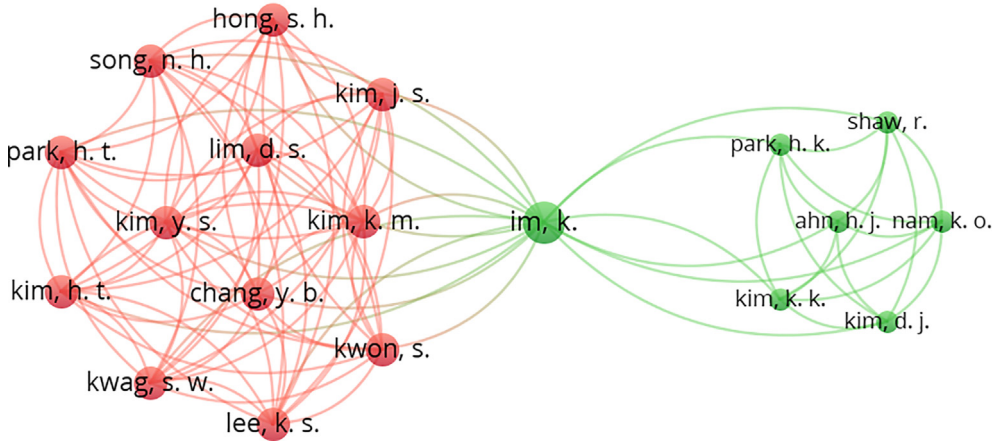

Fig. 2. Authors co-authorship network.

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Table 3
Top 5 publishing institutions.

Organizations	Records
Indian Inst Technol	10
Inst Plasma Res	8
Harbin Inst Technol	5
Czech Tech Univ	4
Harbin Engn Univ	4
Islamic Azad Univ	4
Xi An Jiao Tong Univ	4
Amirkabir Univ Technol	3
Anna Univ	3
Ansys Inc	3
Brno Univ Technol	3
Chinese Acad Sci	3
Coll Engn	3
Concordia Univ	3
Dalian Univ Technol	3
Indian Sch Mines	3
Iter Org	3
Kharazmi Univ Tehran	3
Konkuk Univ	3
Kunming Univ Sci Technol	3
Louisiana State Univ	3
Northeastern Univ	3
Suny Binghamton	3
Wuhan Univ Technol	3
Zhejiang Univ	3

Co-citation analysis is one beneficial strategy used to reveal the underlying intellectual framework of a research topic [23]. A cluster describes a team of co-cited referrals and connections within them as seen by a particular domain [8]. To check out the connections amongst the referenced articles related to ANSYS, which reveals the authors with the highest number of cited articles (Fig. 3). The co-citation network is made of 2 clusters (red and green) having equal number (5) of authors in each. Stepanov, A. A. and Balagansky, I.A. are the top two cited authors, which signifies the quality of research articles they produce.

2.6. Organizations

The organizations that are more active in publishing articles in the related topic are analyzed by contrasting them according to their number of publications. Table 3 list the top 5 institutions which published research articles in the field. It shows up that the Indian Institute of Technology has a total of 10 published articles making it the Institution with the highest number of ANSYS published articles.

2.7. Countries

The country collaboration network of the published documents under the topic "analysis using ANSYS" is presented in Fig. 4. The node size and lines are represented by the number of documents in each country and the collaboration between them. The countries collaboration can be seen to be grouped into about 7 clusters. Certainly, international researchers publishing more on the topic are from, China, India, USA, Korea, Iran and Germany. Amongst the clusters, the least clusters having single countries include Algeria and Ireland which can be seen by the single collaborating lines to only Malaysia.

2.8. Keywords

The frequency of keywords used by the researcher was analyzed. Research trends gaps and future scope can be obtained from the analysis result in both previous and latest published articles. This feature has been provided by the WOS since the year 1990 [24,25]. Fig. 5 shows the keywords network of articles published during the time span. A co-occurrence network was created with clusters that can be linked to certain topics. Similar topics are in the same clusters indicated with same colors. In an effort to track the research topics within the time span the keyword occurrence network is used. Based on the figure, it indicates that the popular keywords are: Finite Element Analysis, Finite Element Method, ANSYS, modal analysis, optimization and CFD. This indicates that they are being used by most published articles under the research topic. The keyword with the largest number is seen to appear in almost all the articles published during the selected period.

3. Conclusion

ANSYS is a general-purpose finite-element modelling plan for numerically addressing a wide range of mechanical problems. The ANSYS program is an effective, multi-purpose evaluation device that can be made use of in a wide array of design techniques. To summarize the progress in the research analysis using ANSYS, this paper presents a bibliometric analysis of the published articles in Web of Science between the year 1989 to date (2019). From the obtained search result, 359 articles were published with single articles published in the first 4 early years. However, there is a rapid rise in the number of published articles from 4 to 10 between the year 2004 and 2005 indicating a rise in interest on the topic. These articles were published in 341 journals which shows multiplicity in publication. Among the total publishing journals, Applied Mechanics and Materials, Advanced Materials

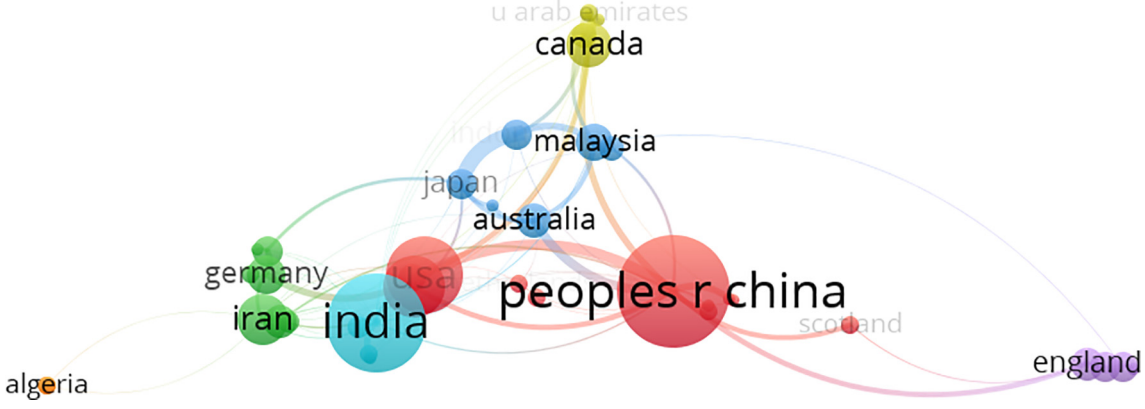

Fig. 4. countries collaboration Network.

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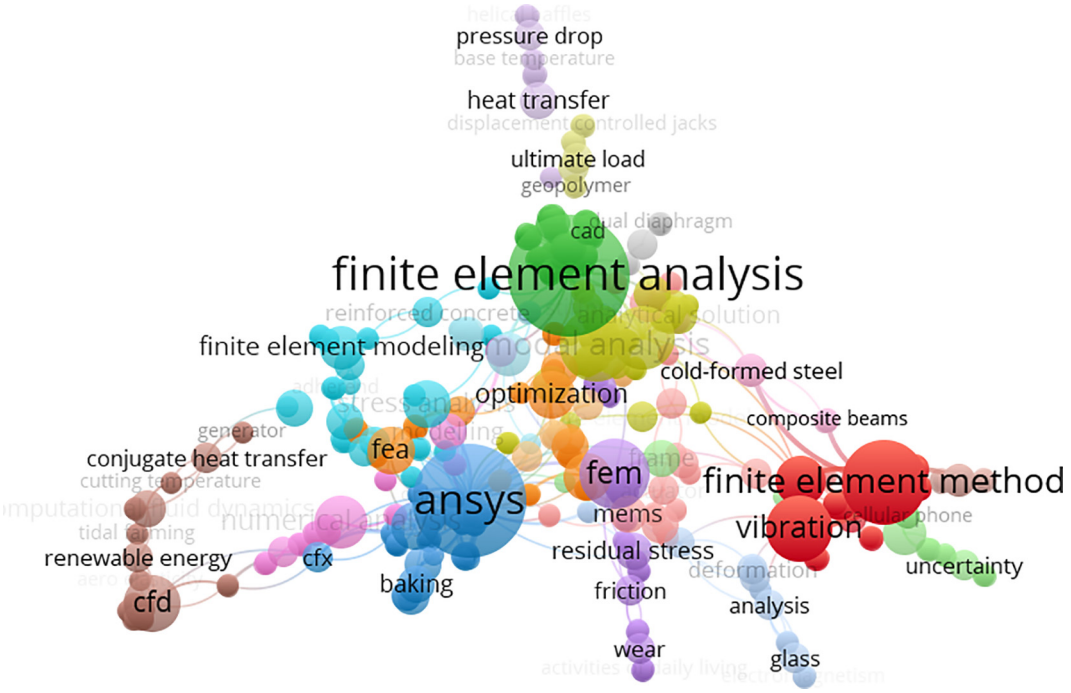

Fig. 5. Authors keyword Network.

Research and Materials Today Proceedings ranked the top 3. Amongst the 1133 authors, Santra P. and Chaudhuri P. emerge as the top 2 with 7 and 6 total publications respectively. Lastly, authors keyword analysis was conducted to reflect the hot trending topics which are Finite element method, ANSYS, optimization and CFD. In general, this paper provides an insight to research towards analysis using ANSYS which will help future researchers to recognize and find suitable research topics collaborators.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors would like to thank Universiti Malaysia Pahang (UMP) for providing the research grant (PGRS1903182) and the facilities.

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